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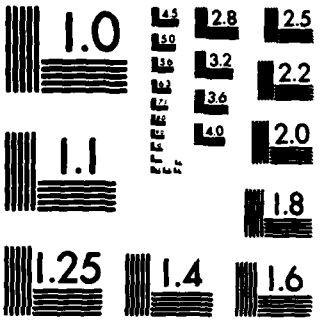

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During this period the single investigator produced two papers with titles, "A differential geometric approach to electromagnetic lens design," and "An anisotropic lens for launching TEM waves on a conducting circular conical system."

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MINIGRANT PROGRAM

AFOSR Grant #83-0040
16 May 1983 - 15 May 1984

A DIFFERENTIAL GEOMETRIC APPROACH TO ELECTROMAGNETIC LENS DESIGN

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The problems investigated under this minigrant arose in the author's research on EM lens design. This research was initiated by the principal investigator under the 1982 Air Force Office of Scientific Research Program, and was concerned with an EM lens design technique developed by C.E. Baum for transitioning TEM waves between cylindrical and conical transmission lines. The method used a differential geometric approach in combination with Maxwell's equations to produce a lens design by specifying the lens material and geometry. The results of the 1982 summer research yielded a class of solutions to the design problem, and these were reported on in Sensor and Simulation Note 282. During the period of the minigrant this note was revised and accepted for publication, under the title "A Differential Geometric Approach to Electromagnetic Lens Design", and will appear in Electromagnetics. The basic idea in this approach is the creation of a class of electromagnetic problems, each having a complicated geometry and medium, which are equivalent to an electromagnetic problem having a simple geometry and medium. One can then utilize solutions of Maxwell's equations in the specification of certain types of EM lenses for transitioning TEM waves, without reflection or distortion, between certain types of transmission lines (e.g., conical and cylindrical).

During the summer of 1983 research was carried out on another EM lens problem in collaboration with C.E. Baum. In this problem a design of an anisotropic lens for launching a TEM wave on a conducting circular conical system was obtained. The method used involved a differential impedance matching and transit-time conservation approach. In essence, this method can be described briefly as follows. A source (see figure) is located at a point P at a distance l below a ground plane AB. A spherical wave front launched at P is to propagate undistorted and unreflected through the lens region PRS into a conical region $QRSA$ with apex at 0. The basic problem is to determine both the shape of the lens and its constitutive parameters as well as the source location. The lens is to be composed of a dielectric whose relative permittivity ϵ_r is to be a function of a single variable θ', and the problem is formulated mathematically by a pair of differential equations which arise from impedance matching and travel time considerations. These equations have the form

$$\frac{d\theta}{d\theta'} = \frac{1}{\sqrt{\epsilon_r(\theta')}} \frac{\sin(\theta)}{\sin(\theta')} \tag{1}$$

$$\frac{d}{d\theta'}\left[r' \sqrt{\epsilon_r(\theta')} - r\right] = 0 \tag{2}$$

where r, r', θ, and θ' are related through the law of sines (see figure)

$$\frac{\sin(\theta-\theta')}{l} = \frac{\sin(\theta)}{r'} = \frac{\sin(\theta')}{r}. \tag{3}$$

An exact solution to this problem was obtained and the relevant details appear in Sensor and Simulation Note 285.

Copies of publications (2) and (3) cited in this report are included in the appendix.

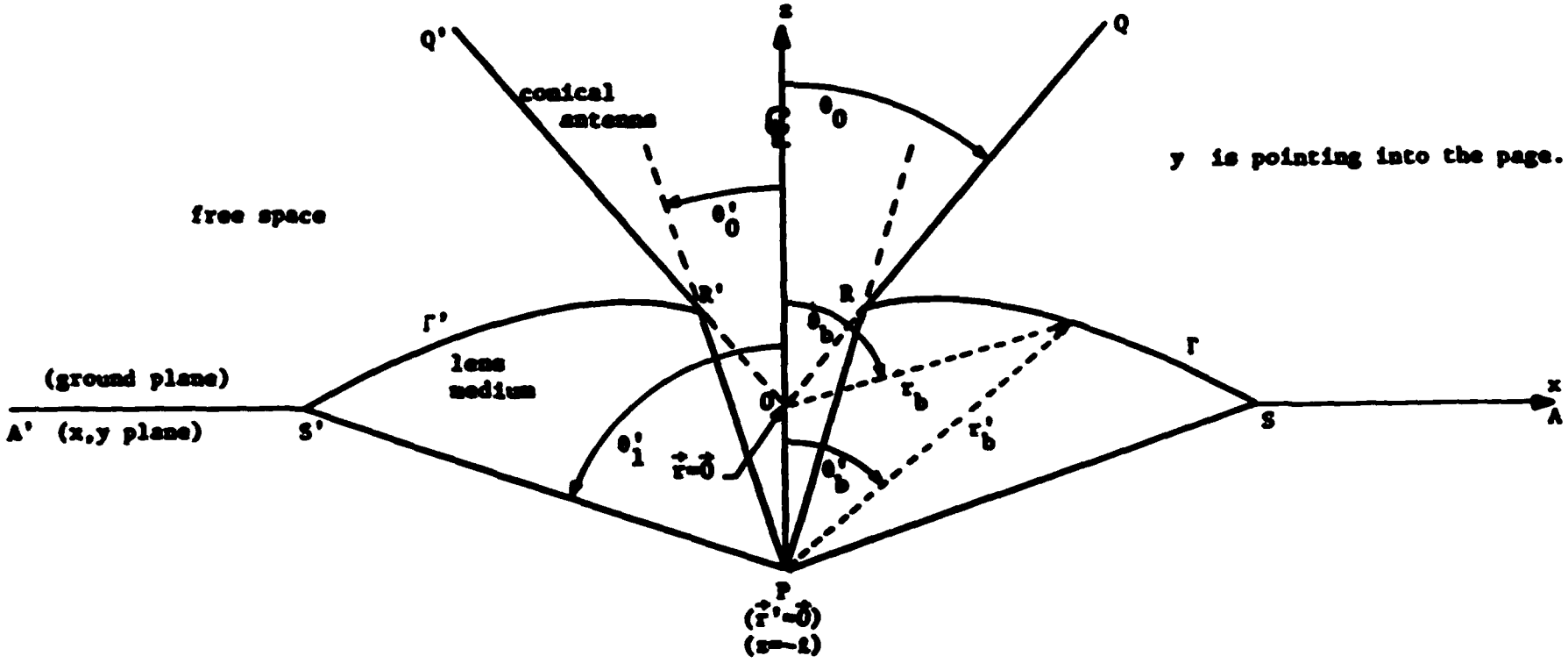
Publications

1. A differential geometric approach to electromagnetic lens design, Sensor and Simulation Note 282, April 1983, Air Force Weapons Laboratory, Kirtland AFB, Albuquerque, NM 87117.

2. A differential geometric approach to electromagnetic lens design, to appear Vol. 4, #1 of Electromagnetics.

•3. An anisotropic lens for launching TEM waves on a conducting circular conical system, Sensor and Simulation Note 285, June 1984, Air Force Weapons Laboratory, Kirtland AFB, Albuquerque, NM 87117.

• (with C.E. Baum): to be submitted in revised form for publication to Electromagnetics.



Figure

Geometry of Circular Conical Lens Feeding Circular Conical Antenna with Ground Plane.